THE APPROACH OF HALLEY'S COMET.

BY RALPH B. LARKIN.

DURING recent years astronomers have been looking forward with high expectancy to the year 1910, for in that year Halley's comet, the most famous in history, is to return. For thousands of years, and millions, for aught we know, this remarkable object has been returning at intervals to the neighborhood of the earth. History records many of its returns. But only within recent times have its visits been predicted and watched for. For until the days of Sir Isaac Newton, during the latter part of the seventeenth century, it was not known that comets moved on established orbits and that some of them returned at regular intervals. Before that time the comet we now call Halley's had been seen at many of its returns and noted in literature. But its appearances were not recognized as those of one object returning periodically.

Halley, Astronomer Royal of England, witnessed a great comet which flashed forth in the heavens in the year 1682. He noted its course through the heavens from night to night, and conceived the idea of comparing its course with those of previous great comets described in history. His materials for purposes of comparison were meagre, for the descriptions of the courses of previous comets were necessarily crude and imperfect. However, he discovered that the courses followed by great comets in the years 1531 and 1607 were similar to the one which he was then observing in 1682. This led him to suspect that they were not different comets, but one and the same. He further saw that there was an interval of about seventy-six years between them. This confirmed him in his belief and led him to predict with confidence that the comet would return about the year 1758. Of his prediction he said: "Wherefore, if it should return according to our

prediction about the year 1758, impartial posterity will not refuse to acknowledge that this was first discovered by an Englishman."

Of course Halley did not live to see his prediction fulfilled, but as the year approached there was great interest manifested in the outcome. Would the comet appear? We can imagine the intense anticipation of astronomers as the time drew near. And they were not disappointed. The comet was discovered on Christmas night, 1758. It was several months before it was in a position favorable for observation. In April and May it attained great brilliancy. Its tail reached a length equal to more than half the distance from the zenith to the horizon. It was a splendid spectacle.

Its return in 1835 or thereabouts was now regarded as a foregone conclusion, and again it came, awakening great interest. After appearing as a small telescopic object, it was observed in its approach for weeks, getting larger and larger as it drew nearer the sun, and gaining constantly in velocity until it swept round the sun and started back on its outward journey, not to appear again until the year 1910.

For nearly thirty-eight years it kept on its outward course, leaving the sun, as it had approached it, with terrific velocity. Its momentum was so great as to carry it many millions of miles beyond the orbit of Neptune, which is about 2,800,000,000 miles from the sun. The gravity pull of the sun constantly retarded the outward progress of the comet and reduced its rate of motion until it turned back upon its course, which is in the form of an ellipse, and started on its return journey. It has now been speeding this way for about thirty-six years at an ever-increasing rate. Astronomers will soon get glimpses of it through their telescopes and photographs of it will be made. It will constantly increase in size until we shall see it in its glory in the heavens as it rushes by us to sweep round the sun.

In past centuries this comet has produced much mental suffering. People in unenlightened ages saw in it a dire portent of evil and were in terror. Its appearance, for example, in 1456 was just at the time when Europe was in consternation at the victorious advance of the Turks, who had just conquered Constantinople. To the "Ave Maria" was added the prayer: "Lord, save us from the Devil, the Turk and the Comet."

Comets, as to their movements, are of two kinds. Those of one kind belong to the solar system and sweep periodically round the sun. Their orbits are closed at both ends—that is to say, they are ellipses. Halley's comet, of course, is of this kind. Comets of the other form of motion are stray wanderers, moving, so far as we know, independently through space. Their wanderings may continue for long periods of time, until they get near enough to our system to feel the gravity influence of our sun sufficiently to be deflected from their courses and drawn in. These approach the sun at great speed (a velocity of more than 350 miles per second has been known), sweep round it, and go away again, never to return. Their orbits seem to resemble either the geometric figure called a parabola or that known as a hyperbola. These figures are closed at only one end, their two arms reaching out into space and never meeting. Hence it follows that comets which hold to such orbits never return. However, if such a comet comes near enough to some of our larger planets to be deflected from its course through the attraction of gravity, the orbit will be changed into an ellipse, which is closed at both ends. The comet will then become a permanent member of the sun's family and will return at intervals. It is not at all improbable that all the periodic comets were captured in this way and forcibly adopted into our family. The "capture" theory is confirmed by the fact that Jupiter, by far the largest of the planets and consequently with the strongest gravity pull, has by far the largest group of periodic comets within the sphere of his influence—that is, with orbits reaching approximately to his orbit.

The velocity of a comet has much to do with the nature of its orbit. No comet on an ellipse can pass the orbit of the earth with a greater rate than twenty-six miles per second, for when a comet reaches this speed it has been demonstrated that it must be at least moving on a parabola. If it much exceed this velocity, it is travelling on a hyperbola.

The nineteenth century witnessed other great comets besides Halley's. The comet of 1811 was a startling apparition, with a tail that at one time measured 100,000,000 miles in length. It was observed for nearly seventeen months. The comet of 1843 was so brilliant as to be visible in full daylight. It was remarkable in that it passed nearer the sun than any other object has ever been known to pass. Donati's comet, in 1858, was 54,000,000

miles in length and was visible to the naked eye nearly four months. Its course was computed, and the comet is expected to return in about 2,000 years. Its journey out into space carries it five times as far from the sun as Halley's comet travels, or about 15,000,000,000 miles. The comet of 1861 was very large. It is worthy of especial note that the earth passed through its tail, but without any discoverable effects. The last great comets, those of 1880 and 1882, are still fresh in the minds of many people. The interval since these last spectacular comets has now grown so long that we welcome the approach of the famous one now near at hand.

Comets are very numerous in space. Kepler thought that space is as full of comets as the sea is full of fish. But we see only a minute portion of the great total. Of those that are seen from the earth almost all are faint telescopic objects. Several of these are found each year, the great majority of which are wanderers and never return to our system.

It will doubtless occur to many to ask whether there is any danger of a comet striking the earth. To this it is to be said that there is such a possibility, but the mathematical chance is so slight as practically to be zero. Babinet estimated that such an event will occur on an average once in about fifteen million years. We shall scarcely need to construct bomb-proofs against such bombardment.

But what would happen if a comet were to strike the earth? To this we cannot make a positive answer, for it suggests another question to which we cannot with entire certainty reply: Of what do comets consist?

Modern astronomy feels confident that it can answer this question with but a small margin of uncertainty. It is known that, while comets are often of great dimensions, they are yet not of great mass. Their tails are made up of highly rarefied matter immensely more attenuated than our atmosphere. This was demonstrated when the earth passed through the tail of the comet of 1861 without noticeable effect. The head of the comet, according to the best present knowledge, is not a solid body, but rather a great swarm of meteoric particles, not in close contact, moving along together, and with the power of emitting light. There is difference of opinion as to the size of these particles. Some hold them to be boulders of various sizes—*i. e.*, meteoroids

similar to those which fall upon the earth and in inconceivable numbers. Others believe the particles to be smaller, so that a comet may be styled a "gravel bank"; others have called it a "dust-cloud." But in any case the head is not a rigid body, and its mass or weight in proportion to its great dimensions is very small. If a comet were of great mass it would be sure materially to influence the movements of planets near which it might pass. But this does not occur. On the contrary, planets very materially influence the movements of comets—for example, Jupiter, which has corralled so many for our system. If a comet were of great mass and were to come near enough to the earth to influence its motion, we might witness the very interesting phenomenon of the earth being hastened or retarded in its progress, and so changing our calendar, making the year have less days or more, as the case might be, than the almanac shows. But comets have not mass enough to produce this result.

If now we ask the effect of a comet's striking the earth, we will readily see that if the head of the comet is composed of boulders a collision would have disastrous consequences. A rain of millions of great meteoric stones would, of course, bring catastrophe. If, however, it were merely a rain of small particles or dust, we might never become conscious of it, for the particles would never reach us. They would be fused into gas through friction with our atmosphere many miles before reaching the surface. If the gases liberated by friction were in excessive volume, we might suffer discomfort or even disaster. It is estimated that hundreds of millions of meteoric particles strike our atmosphere every day. This would be a serious matter if we were not protected by our great sheltering envelope of air. Occasionally a meteoric boulder is large enough to resist the heat generated by this friction and reaches the surface. This we call a meteorite. The now established connection between comets and meteors is a matter of great interest.

A very interesting comet phenomenon is the fact that the tail is not produced by the motion of the head. If a ball of fire were to move rapidly through our atmosphere, we would not be surprised to see a trail of sparks behind brushed off by friction. One might think that the tail of a comet is produced in a similar way, or that the tail would naturally trail behind because of its being lighter in weight. But this is not the case. In absolute space

there is no resistance to produce friction. So far as resistance is concerned, a comet could just as well move tail forward as head forward. And precisely this does actually happen. After a comet has swung round the sun and starts on its outward journey, it moves tail first. Whatever may be the direction of the comet's motion, the tail always points away from the sun. This is caused by bombardment from the sun's rays. The repelling power of light is a demonstrated fact. When this bombardment falls upon the comet the tail, being very highly rarefied, responds most readily and recedes to the opposite side of the head.

Photography is now much used in the study of astronomy. Of many recent comets we have good photographs. But since this art has grown up since Halley's comet disappeared, we have nothing but descriptions and drawings to show how it appeared. We may be sure, however, that on the visit it is about to pay us, it will be compelled to sit for its picture many times. It cannot be predicted with certainty that in appearance it will be just as it has been in its past visits, for comets are erratic creatures and not to be entirely trusted. Sometimes periodic comets show irregularities in the time of their return; sometimes they return with form and appearance changed; and sometimes they fail to appear at all, having been lost in some way or destroyed. We shall live in hope, however, that Halley's comet will not now disappoint us, either in the time of its appearance or its brilliancy.

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